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(54) Porous laminate surface coating method.

(57) A method of applying a thermal barrier coat (38,44) on an exposed side (20) of a porous metal laminate (10) which method includes the steps of spreading on the laminate an air-curable maskant to force maskant into the perforations (22) in the exposed side, removing excess maskant from the exposed side so that maskant plugs (30) remain in the perforations with tops generally coplanar with the exposed side, allowing the maskant to cure, directing bond coat (38) and top coat (44) sprays at the exposed side of the porous laminate to deposit a thermal barrier coat thereon but not on the maskant plugs, and removing the maskant plugs by thermal and chemical treatment or by chemical treatment alone.

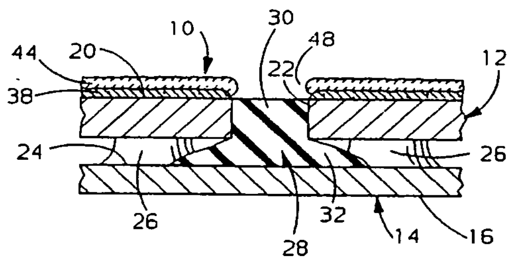

FIG.7

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This invention relates to methods of applying thermal barrier coatings to exposed surfaces of porous metal laminates.

US Patent No. 3,584,972 describes a porous metal laminate suitable for application in high temperature environments of gas turbine engines. The porous metal laminate has a perforated exposed side facing the source of high temperature, a perforated shrouded side exposed to a source of coolant gas such as compressed air, and a plurality of tortuous internal passages between the perforations for conducting coolant from the shrouded side to the exposed side. US Patent No. 4,338,360 describes a method of applying a thermal barrier coat to the exposed side of the porous metal laminate which method minimizes the effect on coolant flow through the laminate caused by barrier coat material deposited on surfaces of the laminate defining air flow paths therethrough. This known method requires a thermal barrier bond coat and a thermal barrier top coat to be sprayed onto the laminate from different directions.

A method according to this invention of applying a thermal barrier coat to an exposed side of a porous metal laminate further reduces deposits of thermal barrier coat material on surfaces of the laminate defining air flow paths through the laminate.

A method in accordance with the present invention is characterised by the features specified in claim 1.

This invention is a new and improved method of applying a thermal barrier coat on an exposed side of a porous metal laminate having a plurality of exposed side perforations through which coolant can be discharged. In the method according to this invention, a viscous spreadable maskant is spread over the exposed side and into exposed side perforations. While the maskant remains spreadable, the exposed side is wiped clean, leaving plugs of maskant in the exposed side perforations in the plane of the exposed side of the porous metal laminate. The maskant plugs are allowed to cure at ambient temperature to an elastomeric consistency in which they adhere to and seal each of the exposed side perforations. Then, the exposed side is mechanically cleaned and roughened and a thermal barrier coat is applied by plasma spray deposition of a bond coat and a ceramic top coat. Following application of the barrier coat, the maskant plugs are removed from the porous metal laminate by thermal degradation and liquid flush or by chemical dissolution without thermal degradation, or by a combination of the two methods.

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a partially broken-away planar view of a representative or generic porous metal laminate;

Figure 2 is a sectional view taken generally along the plane indicated by lines 2-2 in Figure 1;

Figure 3 is a view similar to Figure 2 and showing the porous metal laminate after application of spreadable maskant;

Figure 4 is a view similar to Figure 2 and showing maskant plugs in exposed side perforation of the porous metal laminate;

Figure 5 is a view similar to Figure 4 and showing the porous metal laminate after application of a thermal barrier bond coat layer;

Figure 6 is a view similar to Figure 5 and showing the porous metal laminate after application of a thermal barrier ceramic top coat layer;

Figure 7 is an enlarged view of a portion of Figure 6; and

Figure 8 is a graphical representation comparing air flow across porous metal laminates treated by the method according to this invention with air flow rates across a bare porous metal laminate.

Referring to Figures 1-2, a representative or generic bare porous metal laminate 10 includes a first or inside lamina 12 and a second or outside lamina 14. The designations inside and outside are relative to a source of high temperature such as combustion in a gas turbine engine combustor. Accordingly, the inside lamina 12 is closer to the source of high temperature than the outside lamina 14. The outside lamina has a shrouded side 16 facing a source of coolant such as compressed air and a plurality of shrouded side perforations or pores 18 opening through the shrouded side 16. The shrouded side perforations 18 may have diameters of on the order of 0.5-1.0 mm (0.020-0.040 inch). The inside lamina 12 has an exposed side 20 facing the source of high temperature and a plurality of exposed side perforations or pores 22 opening through the exposed side. The exposed side perforations 22 may have diameters of on the order of 0.25-1.0 mm (0.010-0.040 inch).

The side of the outside lamina 14 opposite the shrouded side 16 is chemically machined to define an etched surface 24 facing the inside lamina 12 and a plurality of dimples 26 which are raised relative to the etched surface 24. The inside and outside lamina 12, 14 are diffusion bonded or brazed at the raised dimples 26 and together define a unitary, rigid laminate. In addition, the shrouded side perforations 18 are offset relative to the exposed side perforations 22 so that coolant flow from the shrouded side perforations to the exposed side perforations is forced to follow tortuous flow paths around the dimples 26. The aforesaid US Patent No. 3,584,972, and US Patent No.

4,004,056, describe additional, representative porous metal laminates.

To enhance or improve the thermal resistance of the porous metal laminate (10), a thermal barrier coat is applied to the exposed side (20) by a method according to this invention including the following process steps.

(A) Commencing with a clean porous metal laminate 10, for example, a laminate which has been conventionally degreased and/or ultrasonically cleaned in acetone, a viscous spreadable maskant 28 is liberally applied to the exposed side 20, Figure 3. In a successful demonstration of the method according to this invention, the maskant was a modified two-part, air-cured silicone rubber based sealant available under the trade name RTV-11 from General Electric Company and the maskant was troweled onto the exposed side 20 to a depth of about 0.5 mm (0.020 inch). The maskant 28 was mixed with pure graphite to modify the viscosity of the maskant which, after troweling, penetrated into the internal passages through each of the exposed side perforations 22. A hardening agent may also be mixed with the maskant 28.

(B) While the maskant 28 remains spreadable, that is, uncured, an excess quantity thereof is wiped or squeegeed from the exposed side 20. Maskant remaining on the laminate 10, then, defines a plurality of maskant plugs 30 in the exposed side perforations 22 the tops of which in the perforations are coplanar with the plane of the exposed side 20, Figures 4 and 7. A plurality of deposits 32 of surplus maskant are captured in the internal passages of the laminate behind the plugs 30.

(C) The maskant plugs 30 and the surplus maskant below the plugs is allowed to cure at ambient temperature. In the aforesaid experimental demonstration, the maskant was allowed to cure overnight to an elastomeric or rubber-like consistency. The cured maskant plugs 30 adhere to the circumferences of the corresponding ones of the exposed side perforations 22 and, accordingly, effectively seal each of the exposed side perforations.

(D) The exposed side 20 is mechanically cleaned and roughened, for example, grit blasted, to assure uniform adhesion of the thermal barrier coat applied in subsequent steps. The elastomeric consistency of the cured maskant plugs 30 is believed to cause cleaning grit striking the plugs to rebound or bounce off of the plugs without significantly damaging or dislodging the plugs from the exposed side perforations 22. Of course, if any minor dislodgment is detected, spreadable maskant can be simply reapplied to the effected plugs and allowed to cure.

(E) At a bond coat station 34, Figure 5, a plasma spray nozzle 36 directs a thermal spray of bond coat at the exposed side 20 of the porous metal laminate 10. A representative bond coat spray used in the aforesaid experimental demonstration was AMDRY 963 (NiCrAlY) Alloy available from Sulzer-Plasma Technik. The bond coat spray is applied to a thickness of about 0.13 mm (0.005 inch) to define a bond coat layer 38, Figures 5 and 7, on the exposed surface 20.

Because the maskant plugs 30 in the exposed side perforations 22 are in the plane of the exposed side 20, the maskant plugs do not shadow the area around the exposed side perforations. Accordingly, there is no restriction on the direction from which the bond coat is sprayed on the exposed side. In the aforesaid experimental demonstration, the bond coat was sprayed perpendicular to the exposed side 20. In addition, the bond coat does not readily adhere to the maskant plugs 30 and it is believed that that incompatibility, along with the velocity of the bond coat particles impacting the maskant plugs, contributes to rebound of almost all impacting particles from the maskant plugs without adhesion to the latter.

(F) At a top coat station 40, Figure 6, a plasma spray nozzle 42 directs a thermal spray of top coat at the exposed side 20 of the porous metal laminate 10. A representative top coat spray used in the aforesaid experimental demonstration is 8 w/0 Yttria-stabilized Zircoa available from Zircoa Div., Didier Werke. The top coat spray is applied to a thickness of about 0.25 mm (0.010 inch) to define a top coat layer 44, Figures 6 and 7, on the bond coat layer 38 on the exposed side 20.

As described above, the maskant plugs 30 do not shadow the area around the exposed side perforations and, therefore, do not restrict the direction from which the top coat is sprayed on the bond coat layer 38. In the aforesaid experimental demonstration, the top coat was sprayed perpendicular to the exposed side 20. In addition, the top coat does not readily adhere to the maskant plugs 30 and it is believed that that incompatibility, along with the velocity of the top coat particles impacting on the maskant plugs, contributes to rebound of almost all impacting top coat particles from the maskant plugs without adhesion to the latter.

It was noted in the aforesaid experimental demonstration that even though top coat and bond coat material does not adhere directly to the maskant plugs 30, top coat may bridge some of the maskant plugs from around the circumferences of the corresponding exposed side perforations 22. Referring to Figure 7, for

example, bond coat does not adhere to the maskant plugs 30 and, therefore, does not encroach beyond the circumferences of the exposed side perforations 22. When the top coat is sprayed over the bond coat, however, top coat may accumulate as an inwardly projecting lip 48.

Because of the small diameters of the exposed side perforations 22, the inwardly projecting lip 48 may occasionally completely shroud a maskant plug 30 even though the top and bond coat layers 44, 38 are not adhered to the maskant plug. Shrouded ones of the maskant plugs 30 are easily identified by dimples in the top coat layer 44. In that circumstance, the succeeding step in the method according to this invention is facilitated by mechanically piercing the top coat layer 44 over the shrouded ones of the maskant plugs 30.

(G) The maskant plugs 30 and surplus maskant deposits 32 in the internal passages are removed from the porous metal laminate 10 by thermal/chemical treatment or by chemical treatment alone. In the aforesaid experimental demonstration, the maskant plugs 30 and deposits 32 were removed from four samples of thermal barrier coated porous metal laminate 10 by four different combinations of thermal/chemical treatments as follows.

(1) A first sample of porous metal laminate 10, having undergone steps (A-F) described above, was maintained at a temperature of 427°C (800°F) for 16 hours in a static oxidizing atmosphere. Thereafter, the porous metal laminate 10 was immersed in an ultrasonic Acetone bath for two hours.

(2) A second sample of porous metal laminate 10, having undergone steps (A-F) described above, was maintained at a temperature of 649°C (1200°F) for 16 hours in a static oxidizing atmosphere. Thereafter, the porous metal laminate 10 was immersed in an ultrasonic Acetone bath for two hours.

(3) A third sample of porous metal laminate 10, having undergone steps (A-F) described above, was maintained at a temperature of 871°C (1600°F) for 4 hours in a static oxidizing atmosphere. Thereafter, the porous metal laminate 10 was immersed in an ultrasonic detergent bath of MICRO DETERGENT, commercially available from Cole-Parmer Instrument Co., for two hours.

(4) A fourth sample of porous metal laminate 10, having undergone steps (A-F) described above, was maintained at a temperature of 871°C (1600°F) for 4 hours in a static oxidizing atmosphere. Thereafter, the laminate was immersed in an ultrasonic detergent bath of MICRO DETERGENT, commercially available from Cole-Parmer Instrument Co., for 14 (fourteen) hours.

As a quantative measure of the success of the method according to this invention, the air flow rates from the shrouded sides 16 to the exposed sides 20 of the four porous metal laminate samples described above were compared with the corresponding air flow rate of an uncoated or bare porous metal laminate. In Figure 8, a curve 50 describes air flow across the bare porous metal laminate sample. A plurality of curves 52, 54, and 56 describe, respectively, air flow across laminate samples treated in accordance with steps (G)(1), (G)(2) and (G)(3) above. A curve 58, virtually coincident with curve 50, describes air flow across a porous metal laminate sample treated in accordance with step (G)(4) above. Curve 58 verifies that a thermal barrier coat may be applied by a method according to this invention to a porous metal laminate with virtually no negative impact on the air flow characteristic of the laminate.

In another experimental demonstration of the method according to this invention, a sample of porous metal laminate 10 coated with bond coat and barrier coat layers according to steps (A-F) described above had the maskant successfully chemically removed without thermal exposure. The coated sample was completely immersed in liquid DYNASOLVE 210 commercially available from Dynaloy, Incorporated, for 7 hours with continuous agitation by a magnetic stirrer. The sample was then rinsed in methanol, submerged in methanol for 1 hour with continuous agitation by a magnetic stirrer, removed from the methanol, blown dry with filtered air, and, finally, ultrasonically cleaned in acetone for 30 minutes.

Claims

1. A method of coating an exposed side (20) of a porous metal laminate (10) with a thermal barrier coat (38,44), the exposed side of the porous metal laminate having a plurality of perforations (22) therein through which are exposed a plurality of internal passages of the porous metal laminate, the method comprising the steps of forming in each of the perforations (22) in the exposed side (20) a plug (30) of curable maskant (28) having an elastomeric consistency after curing and a top surface substantially coplanar with the exposed side; roughening the exposed side; directing (34,36) a bond coat spray toward the roughened exposed side to coat the roughened exposed side with a bond coat layer (38), the bond coat spray impinging on the top surfaces of the maskant plugs and rebounding therefrom sub-

stantially without adhesion thereto so that the top surfaces of the plugs are not coated with said bond coat layer; directing (40,42) a top coat spray of a ceramic top coat toward the bond coat layer on the exposed side to coat the bond coat layer with a thermally resistant ceramic top coat layer (44), the top coat spray impinging on the top surfaces of the maskant plugs and rebounding therefrom substantially without adhesion thereto; and removing the maskant plugs from the porous metal laminate to unblock the internal passages therein and to unblock the perforations (22) in the exposed side.

2. A method as claimed in claim 1, wherein the curable maskant (28) includes a two-part air-cured silicone rubber based sealant.

3. A method as claimed in claim 1 or claim 2, wherein the step of roughening the exposed side (20) consists of mechanically roughening the exposed side.

4. A method as claimed in any one of claims 1 to 3, wherein the step of forming a plug (30) of curable maskant includes the steps of troweling the maskant (28) in an uncured condition onto the exposed side (20) to force the maskant into the perforations (22) in the exposed side; removing excess maskant from the exposed side so that uncured maskant in the perforations extends outward only to substantially the plane of the exposed side; and allowing the maskant to cure.

5. A method as claimed in any one of claims 1 to 4, wherein the step of removing the maskant plugs (30) includes the steps of exposing the porous metal laminate (10) to an elevated temperature of between about 425 and 650 degrees C in a static oxidizing atmosphere for between about 4 and 16 hours; and cleaning the porous metal laminate by immersion in an ultrasonic liquid cleaner bath for of the order of two to fourteen hours.

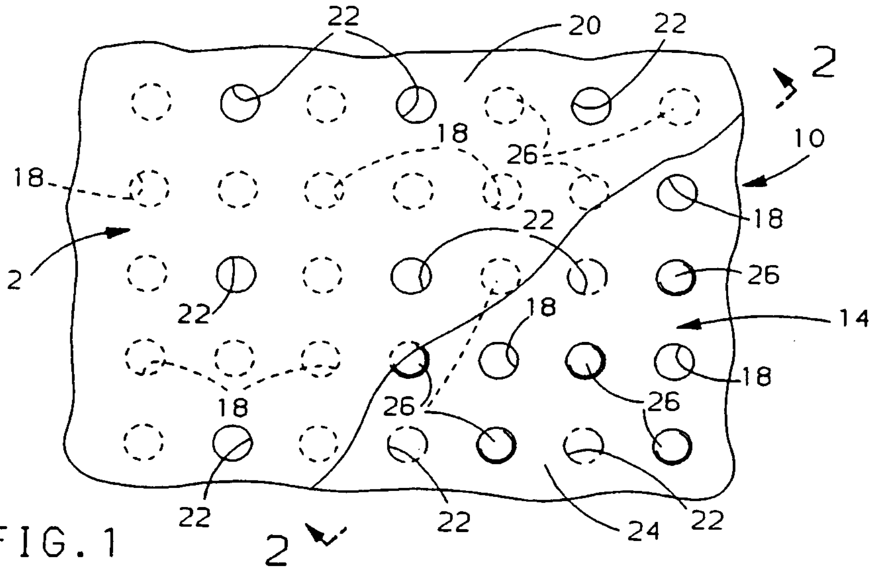

FIG. 1

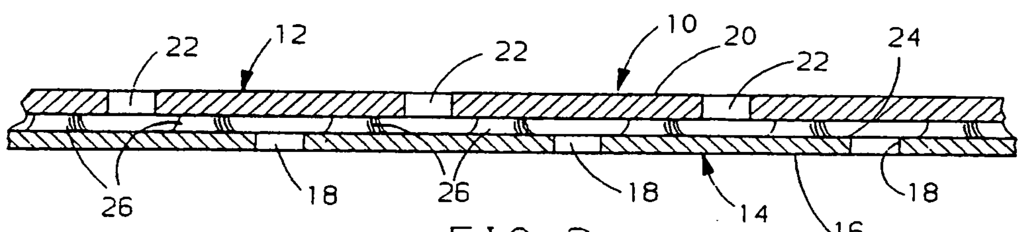

FIG. 2

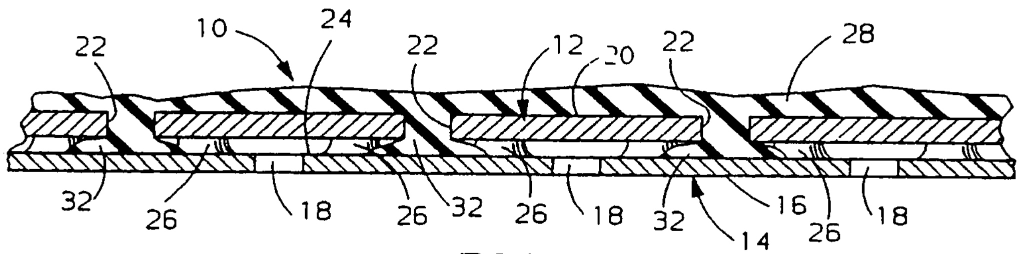

FIG. 3

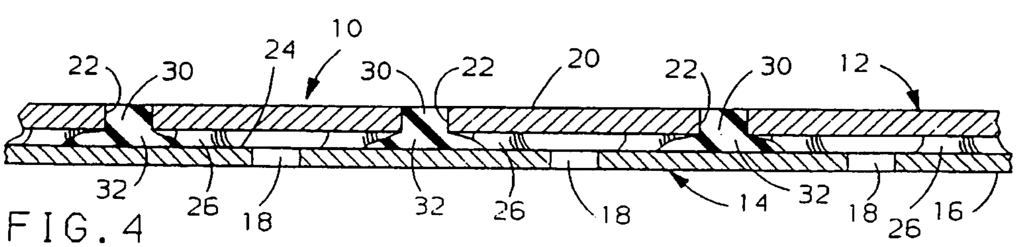

FIG. 4

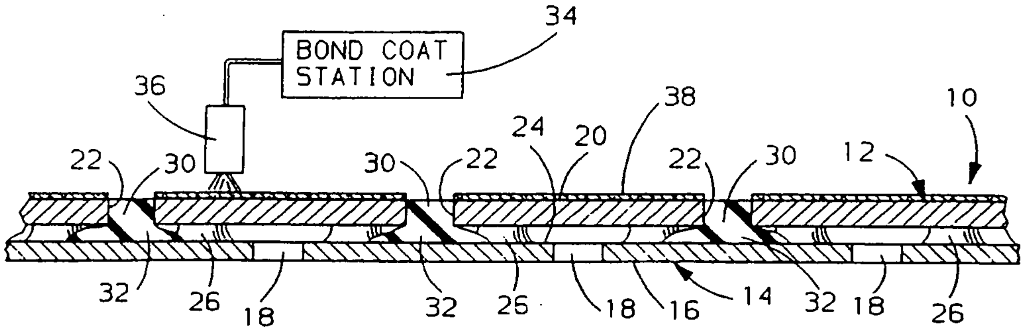

FIG.5

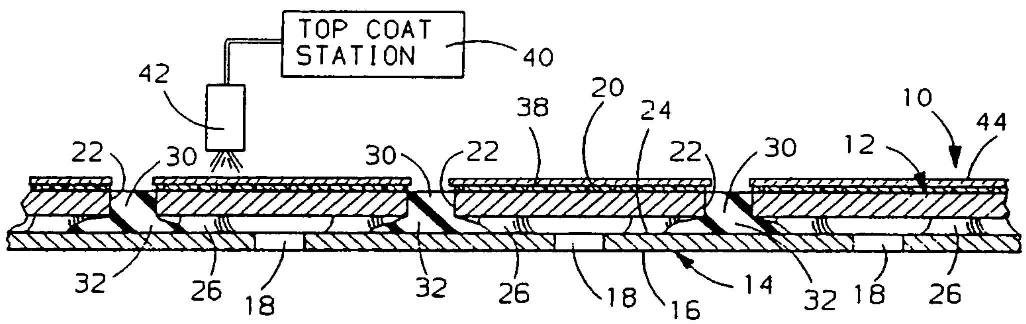

FIG.6

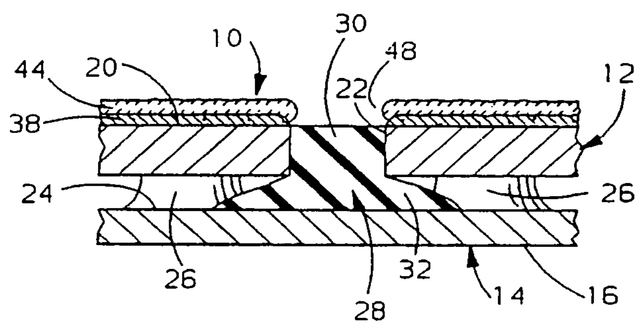

FIG.7

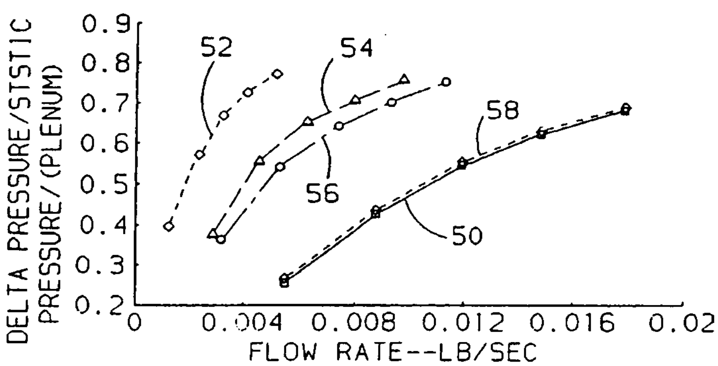

FIG.8

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 20 0812

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 253 754 (UNITED TECHNOLOGIES CORPORATION) * the whole document * ---	1	C23C4/02 C23C4/18 F23R3/00
A,D	US-A-4 338 360 (J.R. CAVANAGH ET AL) * the whole document * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			C23C F23R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 JULY 1992	JOFFREAU P.

CATEGORY OF CITED DOCUMENTS

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